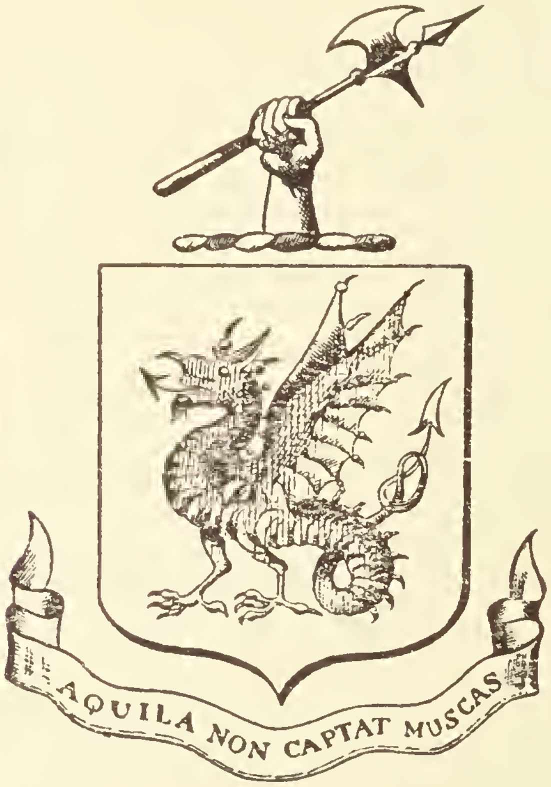

STILLMAN DRAKE

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XIII. *An Account of Experiments made by Mr.* John M^c^ Nab, *at* Henley Houſe, Hudſon's Bay, *relating to freezing Mixtures. By* Henry Cavendiſh, *Eſq. F. R. S. and A. S.*

Read February 23, 1786.

IN my obſervations on Mr. HUTCHINS's Experiments, printed in the LXXIIId volume of the Philoſophical Tranſactions, I gave my opinion concerning the cauſe of the cold produced by mixing ſnow with different liquors. As there were ſome circumſtances, however, which ſeemed to form a difficulty in the way of this opinion, I was deſirous of having further experiments made on the ſubject; and at the ſame time I thought that, by proper management, a greater degree of cold might be produced than had hitherto been done. On mentioning the experiments I wiſhed to have made to Mr. HUTCHINS, he very obligingly deſired Mr. M^c^ NAB, Maſter at Henley-Houſe, to try them; who was ſo good as to undertake the buſineſs, and has executed it in the moſt ſatisfactory manner; as he has not only taken great pains, but has ſhewn the utmoſt attention and accuracy, in obſerving and relating all the phænomena which occurred, and has manifeſted great judgement in frequently adapting the manner of trying the experiments to appearances which occurred in former ones, to which we are indebted for great part of the moſt curious facts in this paper. His endeavours have alſo been attended with much ſucceſs, as he has not only ſhewn many remarkable circumſtances relating to the freezing of the nitrous and vitriolic acids, and the phænomena of freezing mixtures; but has alſo produced degrees of cold greatly ſuperior to any before known.

1. In the above-mentioned Paper I ſaid, that the cold produced by mixing ſpirit of nitre with ſnow, is owing to the melting of the ſnow; and that in all probability there is a certain degree of cold, in which ſpirit of nitre is ſo far from diſſolving ſnow, that it will yield out part of its own water, and ſuffer that to freeze, as is the caſe with ſolutions of common ſalt; ſo that if the cold of the materials, before mixing, is equal to this, no additional cold can be produced. A circumſtance, however, which at firſt ſight ſeems repugnant to this opinion, occurred in an experiment of FAHRENHEIT's for producing cold by a mixture of ſpirit of nitre and ice; namely, that the acid, which had been repeatedly cooled by different frigorific mixtures, was found frozen before it was mixed with the ice; notwithſtanding which, cold was produced by the mixture. Profeſſor BRAUN alſo found, that cold was produced by mixing frozen ſpirit of nitre with ſnow. On conſideration, however, this appeared by no means inconſiſtent with the opinion there laid down, as there was great reaſon to think, that the freezing of the acid was of a different kind from that conſidered in the above-mentioned Paper, and that it did not proceed from the watery part ſeparating from the reſt and freezing; but that the whole acid, or perhaps the more concentrated part, froze; in which caſe it would not be extraordinary that the acid ſhould diſſolve more ſnow, and produce cold.

2. To clear up this point, I ſent to Hudſon's Bay a bottle of ſpirit of nitre, of nearly the ſame ſtrength as FAHRENHEIT's; and deſired Mr. M^c NAB to expoſe it to the cold, and, if it froze, to aſcertain the temperature, and decant the fluid part into

another bottle, and ſend both home to be examined, as it would thereby be known, whether it was the whole acid, or only the watery part, which froze. For the ſame purpoſe alſo I ſent ſome dephlogiſticated ſpirit of nitre of the ſame ſtrength, and alſo ſome ſtrong oil of vitriol. I alſo ſent ſome ſpirit of nitre and ſpirit of wine, both diluted with ſo much water, that it was expected, that with the cold of Hudſon's Bay they would ſuffer the firſt kind of congelation; that is, their watery part would freeze, and thereby make the difference between the two kinds of freezing more apparent.

3. In the ſame Paper I ſay, "That on adding ſnow gra-"dually to ſome of the ſpirit of nitre uſed by Mr. HUTCHINS, "I found, that the addition of a ſmall quantity produced heat "inſtead of cold; and it was not until ſo much was added as to "increaſe the heat from 28° to 51°, that the addition of more "ſnow began to produce cold; the quantity of ſnow required "for this purpoſe being pretty exactly one quarter of the "weight of the ſpirit of nitre, and the heat of the ſnow and "air of the room, as well as the acid, being 28°. The reaſon "of this is, that a great deal of heat is produced by mixing "water with ſpirit of nitre, and the ſtronger the ſpirit is, the "greater is the heat produced. Now it appears from this "experiment, that before the acid was diluted, the heat "produced by its union with the water formed from the melted "ſnow was greater than the cold produced by the melting of "the ſnow; and it was not till it was diluted by the addition "of one quarter of its weight of that ſubſtance, that the cold "generated by the latter cauſe began to exceed the heat gene-"rated by the former. From what has been ſaid, it is evi-"dent, that the cold of a freezing mixture, made with the "undiluted acid, cannot be quite ſo great as that made with

" the ſame acid, diluted with a quarter of its weight of water, " ſuppoſing the acid and ſnow to be both at 28° of heat; and " there is no reaſon to think, that the event will be different if " they are colder; for the undiluted acid will not begin to " generate cold, until ſo much ſnow is diſſolved as to increaſe " its heat from 28° to 51°, ſo that no greater cold will be " produced, than would be obtained by mixing the diluted acid " heated to 51° with ſnow of the heat of 28°. This method " of adding ſnow gradually to an acid, is much the beſt way " I know of finding what ſtrength it ought to be of, in order " to produce the greateſt effect poſſible."

As it ſeemed likely that, by following this method, a greater degree of cold might be produced than had been done hitherto, I ſent three other bottles of ſpirit of nitre and oil of vitriol, all three diluted, but not ſo much ſo, but that I thought they would require a little further dilution, in order to reduce them to their propereſt degree of ſtrength. I alſo ſent a bottle of highly rectified ſpirit of wine, and a mixture of equal quantities of the above-mentioned common ſpirit of nitre and oil of vitriol; and deſired Mr. Mc NAB to find what degree of cold could be produced by mixing them with ſnow, after having firſt reduced them, in the above-mentioned manner, to their beſt degree of ſtrength *.

He was alſo deſired to aſcertain how much ſnow he added; for as their ſtrength was determined before they were ſent out, it would thereby be known what was the beſt ſtrength of theſe liquors for frigorific mixtures.

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* This might have been done at home; but I thought it not unlikely that the ſtrength found this way might differ, in ſome meaſure, according to the heat in which the experiment was tried.

All theſe bottles were numbered with a diamond; and as I ſhall ſometimes diſtinguiſh them by theſe numbers, and as it may be of uſe to thoſe who may conſult the original, I have added the following liſt of theſe bottles, with their contents.

N°	Liquors mentioned in Art. 3.	Weight of marble which they diſſolve.	Specific gravity at 60° of heat.
168	Spirit of nitre,	,582	1,4371
27	Dephlogiſticated ſpirit of nitre,	,53	1,4040
103	Diluted oil of vitriol,	,654	1,5596
28	Equal weights of N° 168. and N° 103.	– – –	– –
8	Very highly rectified ſpirit of wine,	– – –	,8195
	Liquors mentioned in Art. 2.		
151	Strong oil of vitriol,	,98	1,8437
142	Spirit of nitre,	,525	1,4043
139	Some of the ſame diluted with twice its weight of water,	– – –	– –
141	Dephlogiſticated ſpirit of nitre,	,53	1,4033
143	Some of the ſame ſpirit of wine as in N° 8. diluted with $1\frac{1}{2}$ its weight of water,	– – –	– –
72	Diluted oil of vitriol for comparing the thermometers,	,629	– –
171	Oil of vitriol of about the uſual ſtrength, but the exact ſtrength not known, intended to refreſh the former when too weak.		

4. Profeſſor BRAUN ſays, that by mixtures of ſnow and ſpirit of nitre he ſunk thermometers filled with oil of ſaſſafras, and ſome other eſſential oils, to – 100° or – 124°; and that, by the ſame means, he ſunk thermometers filled with the higheſt rectified ſpirit of wine to – 148°. Though there ſeemed great reaſon to think, from Mr. HUTCHINS's experiments, that there muſt be ſome miſtake in this; yet, as it was poſſible that the eſſential oils, and even ſpirit of wine of a ſtrength much different from that with which Mr. HUTCHINS's thermometers were filled, might follow a conſiderably different progreſſion in their

contraction by great degrees of cold, I ſent a thermometer filled with oil of ſaſſafras, and two others with ſpirits of wine. One of theſe laſt was filled with the higheſt rectified ſpirits I could procure, its ſpecific gravity at 60° of heat being ,8185; the other was intended to be filled with common ſpirits, though from circumſtances I am inclined to ſuſpect *that* alſo to have been filled with the beſt ſpirits. Beſides theſe, there was ſent a mercurial thermometer, accurately adjuſted, according to the directions of the Committee of the Royal Society, printed in the LXVIIth volume of the Tranſactions; and alſo the two ſpirit thermometers uſed by Mr. HUTCHINS, which were filled with ſpirits whoſe ſpecific gravity was ,8247.

5. Theſe thermometers were compared together by expoſing them to the cold, with their balls immerſed in a glaſs veſſel filled with diluted oil of vitriol. They were at times alſo compared in cold more violent than the natural cold of the climate, by adding ſnow to the acid in which they were tried, in which caſe care was taken to keep the mixture frequently ſtirred. Oil of vitriol was recommended for this purpoſe, as a fluid which would moſt likely bear any degree of cold without freezing, and whoſe natural cold might be much increaſed by the addition of ſnow. It ſeems to have anſwered the purpoſe very well, and not to have been attended with any inconvenience.

During the firſt compariſon of theſe thermometers, a whitiſh globule, ſuch as thoſe which appear in frozen oil, was obſerved in the tube of the thermometer filled with oil of ſaſſafras. This appearance of congelation did not much increaſe; but two days after a large air bubble was found in its ball, which prevented Mr. M^c NAB from making further obſervations with it.

It is well known, that ſpirit of wine expands more by a given number of degrees of a mercurial thermometer in warm temperatures than in cold ones; and this inequality, as might be expected, was leſs in the ſtronger ſpirit than in the weaker, but the difference was inconſiderable. The oil of ſaſſafras alſo had ſome of this inequality, but much leſs. It however appears to be by no means a proper fluid for filling thermometers with. No appearance was obſerved which indicates any conſiderable irregularity in the contraction of ſpirits of wine in intenſe cold, or which renders it probable, that thermometers filled therewith could be ſunk by a mixture of ſnow and ſpirit of nitre to a degree near approaching to that mentioned by Profeſſor BRAUN.

6. Mr. M^c^ NAB in his experiments ſometimes uſed one thermometer and ſometimes another; but in the following pages I have reduced all the obſervations to the ſame ſtandard; namely, in degrees of cold leſs than that of freezing mercury I have ſet down that degree which would have been ſhewn by the mercurial thermometer in the ſame circumſtances; but as that could not have been done in greater degrees of cold, as the mercurial thermometer then becomes of no uſe, I found how much lower the mercurial thermometer ſtood at its freezing point, than each of the ſpirit thermometers, and increaſed the cold ſhewn by the latter by that difference.

On the common and dephlogiſticated Acids of Nitre.

The following experiments ſhew, that both theſe acids are capable of a kind of congelation, in which the whole, and not merely the watery part, freezes. Their freezing point alſo differs greatly according to the ſtrength, and varies according to a very unexpected law. Like water too they bear being cooled very much below their freezing point before the congelation begins, and as ſoon as that takes place, immediately riſe up to the freezing point.

7. On the morning of Feb. 1. the common and dephlogiſticated ſpirits of nitre, N° 142 and 141, whoſe ſpecific gravities were 1,4043 and 1,4033, were found clear and fluid, the cold of the air at that time being − 47°. They alſo bore being ſhook without any alteration; but on taking out their ſtoppers, both of them in a few minutes began to freeze, the congelation beginning by a white appearance at top, which gradually ſpread to the bottom; and they became ſo thick as not to move on inclining the phial. For want of a thermometer whoſe ball reached far enough below its ſcale, Mr. M^c NAB was not able to determine their cold while in the bottle; but in ſomewhat more than an hour's time, the frozen acid had ſo much ſubſided as to admit of his pouring a little fluid matter out of each into a glaſs with a thermometer in it*; whereby the cold of the common ſpirit of nitre was found to be − 31°½, and that of the dephlogiſticated acid − 30°, the temperature of the air being − 41°. Each of theſe decanted liquors, at the time their temperature was tried, was full of ſmall *ſpicula* of ice: they were then put into phials well ſtopped, and they, as well as the undecanted liquors, ſent home to be examined. The decanted part of the common

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* It may be aſked, why it was more poſſible to decant any liquor at this time than at firſt, as the acid was all the while expoſed to a cold much below the freezing point? The reaſon in all probability is, not that any part of the ice firſt formed diſſolved, but that the ſmall filaments into which it ſhot collected together, and in ſome meaſure ſubſided to the bottom.

ſpirit of nitre diſſolved ,535 of its weight of marble, and the undecanted part ,523; for which reaſon I ſhall call the ſtrength of the former ,535, and that of the latter ,523; which mode of reckoning is obſerved in the remainder of this Paper. The ſtrength of the decanted part of the dephlogiſticated acid was ,56, and that of the undecanted part ,528; ſo that it appears that in each of theſe acids the unfrozen part was a little ſtronger than the frozen part. It is remarkable, that in the common ſpirit of nitre, the decanted part, though ſtronger than the other, was paler coloured and leſs fuming.

8. On Dec. 21, the temperature of the air being – 28°, ſome dephlogiſticated ſpirit of nitre (N° 27.) of nearly the ſame ſtrength as the former acid, was poured into a jar, in order to be diluted with ſnow, as recommended in Art. 2. Immediately after it was decanted, it began to freeze, in the ſame manner as before deſcribed, except that a leſs portion of it ſeems to have congealed: its temperature, tried by dipping a thermometer into it, was – 19°, where it remained ſtationary for many minutes; it was then diluted with ſnow, as will be mentioned in Art. 14. whereby its ſtrength was reduced to ,434.

9. On Dec. 29th, this diluted acid was completely melted, and half of it poured into a jar with a ground ſtopper, and both portions expoſed to the air. In the morning they were perfectly fluid; but on taking the ſtopper out of the jar, and dipping in it a thermometer, the acid immediately froze, beginning by forming a white coat round the ball of the thermometer, which gradually ſpread through the whole fluid; and at the ſame time the thermometer roſe till it ſtood ſtationary at – 5°. The cold of the acid before it began to freeze muſt have been about – 30°½, that being the temperature of a

glaſs of vitriolic acid ſtanding near it; but the thermometer which was dipped into it was five or ſix degrees colder, which ſeems to be the cauſe of the congelation beginning round the ball.

In the afternoon a thermometer was dipped into the other half of the acid, where, as the weather had grown leſs cold, it ſtood above a minute at – 25°, without freezing; then, however, the acid froze, with the ſame appearance as in the morning, and at the ſame time the thermometer roſe to – 4°, and became ſtationary.

This acid, being left in the air with the thermometer in it, was found in the evening at – 45°; it however was not intirely frozen, being only thick as an unguent, which ſhews that the unfrozen part muſt have been of a different ſtrength from the frozen part; but it does not appear whether ſtronger or weaker. The next morning it was frozen ſolid, though the cold was only half a degree greater.

On Jan. 16th, this acid was again tried in the ſame manner; it then ſuffered a thermometer, whoſe ball had been previouſly warmed in the hand, to be dipped into it, and remain there ſeveral minutes without freezing, though its temperature was – 35°. But on lifting up the thermometer, a drop fell from its ball into the acid, which immediately ſet it a freezing, and it roſe up to – 4°½.

10. On Dec. 22d, the ſpirit of nitre (N° 168.) which a few days before had been diluted with ſnow, ſo as to be reduced to the ſtrength of ,411, was divided into two equal parts, and expoſed to the cold. On Dec. 29th, when the temperature of the air was – 17°½, one of theſe parts was found beginning to freeze; the other was fluid, but began to freeze on dipping in a thermometer; the thermometer in both kept ſtationary at

$-1°\frac{1}{2}$. The latter was twice re melted and expoſed to the cold, and both times the temperature of the frozen acid came out the ſame as before.

11. The white colour of the ice in theſe experiments ſeems owing only to its conſiſting of very ſlender filaments; for in ſome caſes, where it froze ſlower, and where, in conſequence, it ſhot into larger ſolid maſſes, they were tranſparent, and of the ſame colour as the acid itſelf. By the continuance of a ſufficient cold, the acid, which by haſty freezing put on the white appearance, would become hard ſolid ice, but yet ſtill retained its white appearance, owing perhaps to the filaments firſt ſhot conſiſting of an acid differing in ſtrength from that which froze afterwards, and filled up the interſtices.

In all theſe experiments, whether the ice was formed into minute filaments or ſolid maſſes, ſtill, whenever there was a ſufficient quantity of fluid matter to admit of it, they conſtantly ſubſided to the bottom; a proof that the frozen part was heavier than the unfrozen. The difference indeed is ſo great, that in one caſe where it froze into ſolid cryſtals on the ſurface, theſe cryſtals, when detached by agitation, fell with force enough to make a tinkling noiſe againſt the bottom of the glaſs.

Theſe acids contract very much on freezing. Whenever the acid is frozen ſolid, the ſurface, inſtead of being elevated in ridges, like frozen water, is depreſſed and full of cracks. In one experiment Mr. M^c^ NAB, after a glaſs almoſt full of acid was nearly frozen, filled it to the brim with freſh acid; and then, after it was completely frozen, the ſurface was viſibly depreſſed, with fiſſures one-eighth of an inch broad, extending from top to bottom. It is this contraction of the acid in freezing which makes the frozen part ſubſide in the fluid part; as it was found, in the undiluted acid, that the latter conſiſted of a ſtronger, and conſequently heavier, acid than the former. But ſtill the ſubſidence of the frozen part ſhews, that the ice is not mere water, or even a very dilute acid; which indeed was proved by the examination of the liquors ſent home.

The ninth and tenth articles ſhew, that though the acids bear being cooled greatly below the freezing point, without any congelation taking place, yet as ſoon as they begin to freeze they immediately riſe up to their freezing point; and this point is always very nearly, if not exactly, the ſame in the ſame acid; for thoſe acids were frozen and melted again three or four times, and were cooled conſiderably more below the freezing point in one trial than another, and yet as ſoon as they began to freeze the thermometer immerſed in them conſtantly roſe nearly to the ſame point.

The quantity which theſe acids will bear being cooled below the freezing point, without freezing, is remarkable. The diluted ſpirit of nitre, whoſe freezing point is $-1^\circ\frac{1}{2}$, once bore being cooled to near -39°, without freezing, that is, near 37 degrees below its freezing point. The diluted dephlogiſticated ſpirit of nitre, whoſe freezing point is -5°, bore cooling to -35°; and the dephlogiſticated ſpirit of nitre (141) whoſe true freezing point is moſt likely -19° *(ſee next article)* bore being cooled to -49°: perhaps too they might have born to be cooled conſiderably lower without freezing, but how much does not appear. It muſt be obſerved, however, that the ſame diluted ſpirit which at one time bore being cooled to -39°, at another froze, without any apparent cauſe, when its cold was certainly leſs than -30°, and moſt likely not much below -18°.

12. The freezing point differs remarkably, according to the ſtrength of the acid. In the diluted dephlogiſticated and common ſpirit of Art. 7. and 8. the freezing point was – 5° and – 1°½. In the dephlogiſticated and common ſpirit of Art. 5. the decanted parts of which were ſtronger than the foregoing in ſcarcely ſo great a proportion as that of four to three, it ſeemed to be – 30° and – 31°½. It may indeed be ſuſpected, that as this point was determined only by pouring a ſmall quantity of the acid into a glaſs, at a time when the air and glaſs were much colder than the acid, theſe decanted liquors might be cooled by the air and glaſs, and thereby make the freezing point appear lower than it really was: but I do not think this could be the caſe; for as the decanted liquors were full of ſmall filaments of ice, they could hardly be cooled ſenſibly below their freezing points without freezing; and any cold, communicated to them by the air or glaſs, would ſerve only to convert more of them into ice, without ſenſibly increaſing their cold: ſo that I think this experiment determines the true freezing point of their decanted part; but it muſt be obſerved, that as the decanted part was rather ſtronger than the reſt, it is very poſſible that the freezing point of the undecanted part might be conſiderably leſs cold.

A circumſtance which might incline one to think, that the way by which the freezing point was determined in this experiment is defective is, that the freezing point of the dephlogiſticated acid N° 27. though nearly of the ſame ſtrength as that laſt mentioned, but rather ſtronger, was much leſs low, being only – 19°. But I have little doubt that the true reaſon of this is, that in the former acid the ſtrength of the decanted part, which is the part whoſe freezing point was tried, was found to be at leaſt $\frac{1}{20}$ greater than that of the whole maſs; whereas in N° 27. the fluid part was in all probability not ſenſibly ſtronger than the whole maſs; for as N° 27. was cooled only ſeven degrees below the freezing point, and its temperature was tried ſoon after its beginning to freeze, not much of the acid could have frozen; whereas the other was cooled 15 degrees below its freezing point, and was expoſed for an hour or two to an air not much leſs cold, in conſequence of which a conſiderable part of the acid muſt have frozen; ſo that in all probability the acid, whoſe freezing point was found to be – 30°, was in reality $\frac{1}{20}$ part ſtronger than that whoſe freezing point was – 19°.

If this reaſoning be juſt, the freezing point of theſe acids is as follows:

		Freezing point.
Dephlogiſticated ſpirit of nitre, whoſe ſtrength =	,56	– 30°
	,53	– 19
	,437	– 4½
Common ſpirit of nitre, whoſe ſtrength =	,54	– 31½
	,411	– 1½

On the Phænomena obſerved on mixing Snow with theſe Acids.

13. On Dec. 13, ſnow was added to the ſpirit of nitre N° 168, as recommended in Art. 2. The ſnow was put in very gradually, and time was taken to find what effect each addition had on the thermometer and mixture, before more was added. The temperature of the acid before the mixture was – 27°, and each addition of ſnow raiſed the thermometer a little, till it roſe to – 1°¼; after which the next addition made it ſink to – 2°, which ſhewed that ſufficient ſnow had then been added. The

quantity of ſnow uſed was pretty exactly $\frac{4}{10}$ of the weight of the acid, the weight of the acid being 13 oz. ſo that the ſtrength of the diluted acid was reduced to ,411.

The acid before the addition of ſnow had no ſigns of freezing, its temperature being in all probability much above its freezing point; yet the ſnow did not appear to diſſolve, but formed thin white cakes, which however did not float on the ſurface, but fell to the bottom, and when broke by the ſpatula formed a gritty ſediment; ſo that it appears, that theſe cakes are not ſimply undiſſolved ſnow, but that the adjoining acid abſorbed ſo much of the ſnow in contact with it, as to become diluted ſufficiently to freeze with that degree of cold, and then congealed into theſe cakes. The quantity of congealed matter ſeems to have kept increaſing till the end of the experiment.

14. On Dec. 21, an experiment was made in the ſame manner with the dephlogiſticated ſpirit of nitre N° 27. The acid began to freeze in pouring it into the jar in which the mixture was to be made, and ſtood ſtationary there at $-19°$, as related in Art. 6.; ſo that the liquor at the beginning of the experiment was white and thick, which made the effect of the addition of the ſnow leſs ſenſible. However, the congealed matter conſtantly ſubſided to the bottom, and the quantity ſeems to have continued increaſing to the end of the experiment. The heat of the mixture roſe to $-4°$ before cold began to be produced, and the quantity of ſnow added was $\frac{22}{100}$ of that of the acid, ſo that the ſtrength of the acid was reduced to ,437 by the dilution.

A very remarkable circumſtance in this experiment is, that the acid, while the ſnow was adding, firſt became of a yellowiſh,

lowiſh, and afterwards of a greeniſh or bluiſh hue. This colour did not go off by ſtanding, but continued at leaſt ten days, during which time the acid conſtantly kept that colour, except when by haſty freezing it ſhot into ſmall filaments, in which caſe it put on the white appearance which theſe acids always aſſumed under thoſe circumſtances; but once that by gradual freezing it ſhot into tranſparent ice, this ice was of a bluiſh colour.

It is difficult to conceive what this colour ſhould proceed from. Spirit of nitre is well known to aſſume this colour when much phlogiſticated and properly diluted; but one does not ſee why it ſhould become phlogiſticated by the addition of the ſnow, and ſtill leſs why the dephlogiſticated acid ſhould become more phlogiſticated thereby than the common acid did; for though it is not extraordinary, that a proceſs not capable of producing any increaſe of phlogiſtication in the common acid, ſhould make this as much phlogiſticated as that, yet it is very extraordinary that it ſhould make it more ſo. No notice is taken of any effervеſcence or diſcharge of air while it was aſſuming this colour, nor was it obſerved that it became more ſmoking thereby, or that the top of the phial in which it was kept became full of red fumes, as might naturally be expected if it was rendered much phlogiſticated. Theſe are circumſtances which, conſidering Mr. M^c^ NAB's great attention to ſet down all the phænomena that occurred, I ſhould think would hardly have been omitted if they had really happened.

15. It is remarkable, that in both theſe experiments the addition of ſnow produced heat, until it arrived pretty exactly at what was found to be the freezing point of the diluted acid; but that as ſoon as it arrived at that point, the addition of more ſnow began to produce cold. This can hardly be owing

merely to accident, and to both acids having happened to be of that preciſe degree of heat before the experiment began, that their heat after dilution ſhould coincide with the freezing point anſwering to their new ſtrength. The true cauſe ſeems to be as follows. It will be ſhewn in Art. 16. and 17. that the freezing point of theſe acids, when diluted as in the foregoing experiments, is much leſs cold than when they are conſiderably more diluted; and it was before ſhewn to be much leſs cold than when not diluted; ſo that there muſt be a certain degree of ſtrength, not very different from that to which theſe acids were reduced by dilution, at which they freeze with a leſs degree of cold than when they are either ſtronger or weaker. Now in theſe experiments, the temperature of the liquors before dilution was below this point of eaſieſt freezing, and a great deal of the acid was in a ſtate of congelation all the time of dilution; the conſequence of which is, that when they were diluted to the ſtrength of eaſieſt freezing, they would alſo be at the heat of eaſieſt freezing; for they could not be below that point, becauſe, if they were, ſo much of the acid would immediately freeze as would raiſe them up to it; and they could not be above it, for, if they were, ſo much of the congealed acid would diſſolve as would ſink them down to it. After they were arrived at this ſtrength of eaſieſt freezing, the addition of more ſnow would produce cold, unleſs this ſtrength be greater than that at which the addition of a ſmall quantity of ſnow begins to produce cold; but even were this the caſe, heat would not be produced, but the temperature of the acids would remain ſtationary until they were ſo much diluted that the addition of more ſnow ſhould produce cold. So that, in either caſe, the heat of the acids, at the time that the addition of freſh ſnow began to produce cold, muſt be that of eaſieſt freezing; and conſequently, as this heat was found to coincide very nearly with the freezing point of theſe acids, after dilution, it follows that their ſtrengths at that time could differ very little from the ſtrength of eaſieſt freezing.

If the temperature of the liquors at the beginning of the experiment had been above the point of eaſieſt freezing, none of the acid would have congealed during the dilution, and nothing could have been learnt from the experiment relating to the point of eaſieſt freezing; but the heat would have kept increaſing, till the acid was diluted to that degree of ſtrength at which the cold produced by the diſſolving of the ſnow was juſt equal to the heat produced by the union of the melted ſnow with the acid *; after which the addition of more ſnow would begin to produce cold. When I recommended this method of finding the beſt ſtrength of ſpirit of nitre for producing cold, by the addition of ſnow, I was not aware of any impediment from the freezing of the acid, in which caſe it would have been a very proper method; but on account of this circumſtance it can hardly be conſidered as ſuch, except when the cold of the acid at ſetting out is leſs than that of eaſieſt freezing.

In the dephlogiſticated ſpirit of nitre the freezing points anſwering to the ſtrength of ,434, ,53, and ,56, were ſaid to be $-4^\circ\frac{1}{2}$, -19°, and -30°; and the differences of -30° and -19° from $-4^\circ\frac{1}{2}$ are to each other very nearly in the duplicate ratio of ,126 and ,096, the differences of the correſponding ſtrengths from ,434; which, as ,434 is the ſtrength of eaſieſt freezing, is the proportion that might naturally be

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* In the experiment related in my obſervations on Mr. HUTCHINS's Experiments, this ſtrength was rather greater than that of eaſieſt freezing: but whether it is ſo in degrees of cold exceeding that in which my experiment was tried, does not appear.

expected,

expected, and conſequently ſerves in ſome meaſure to confirm the reaſoning in this and the 12th Article.

16. After Mr. M^c Nab had diluted theſe acids as above-mentioned, he divided each of them into two parts, and tried what degree of cold could be produced by mixing them with ſnow. On January 15th, one of theſe parts of the common ſpirit of nitre was tried. It was fluid when the experiment began, though its temperature, as well as that of the ſnow, was $-21°\frac{1}{2}$; but on adding ſnow it immediately began to freeze, and grew thick, and its heat increaſed to $-2°\frac{1}{2}$; but by the addition of more ſnow it quickly ſunk again, and at laſt got to $-43°\frac{1}{4}$. During the addition of the ſnow, the mixture grew thinner, and by the time it arrived at nearly the greateſt degree of cold, conſiſted viſibly of three parts: the loweſt part, which conſiſted of frozen acid, was white and felt gritty; the upper part, which occupied about an equal ſpace, was alſo white, but felt ſoft, and muſt have conſiſted of unmelted ſnow; the other part, which occupied by much the ſmalleſt ſpace, was clear and fluid. The quantity of ſnow added was about $\frac{9}{13}$ of the weight of the acid, and conſequently its ſtrength was reduced to ,243.

Though ſnow was added to the acid in this experiment as long as, and even longer than, it produced any increaſe of cold, yet ſome days after, on adding more ſnow to the mixture, while it was fluid, and of the temperature of $-40°\frac{3}{4}$, the cold was increaſed to $-44°\frac{1}{4}$, or 1 degree lower than before. Mr. M^c Nab did not perceive the ſnow to melt, though in all probability ſome muſt have done ſo, or no cold would have been produced.

The cauſe of this ſeems to be, that in the preceding experiment the congealed part of the acid was ſtronger than the fluid part; ſo that, though the fluid part was not ſtrong enough to diſſolve ſnow in a cold greater than $-43^{\circ}\frac{1}{4}$, yet the whole acid together was ſtrong enough to do it in a cold one degree greater.

A circumſtance occurred in the laſt experiment which I cannot at all ſee the reaſon of; namely, a ſmall part of the acid being poured into a ſaucer, before the addition of the ſnow, it was in an hour's time changed into ſolid ice, though the cold of the air, at the time the acid was poured out, was only $-41^{\circ}\frac{1}{4}$, and does not ſeem to have increaſed during the experiment.

17. On December 30, the other half of the ſame acid had been tried in the ſame manner; at the beginning of the experiment not more than one-ninth part of the acid was fluid, the reſt ſolid clear ice; its temperature was $-34^{\circ}\frac{1}{2}$, and that of the ſnow nearly the ſame; the greateſt degree of cold produced was $-42^{\circ}\frac{3}{4}$; and the quantity of ſnow employed was about one-eighteenth of the weight of the acid; ſo that the ſtrength of the mixture was ,38. The freezing point of the acid thus diluted appears to be about $-45^{\circ}\frac{1}{4}$; for by the increaſe of warmth during the day-time, moſt of the congealed matter diſſolved; but in the evening it began to freeze again, ſo as to become thicker, its temperature being then $-45^{\circ}\frac{1}{4}$; and the next morning it was frozen ſolid, its cold being one degree greater.

18. On December 12, the diluted ſpirit of nitre N° 139. whoſe ſtrength was ,175, was found frozen, its temperature being -17. The fluid part, which was full of thin flakes of clear ice, and was of the conſiſtence of ſyrup, was decanted into another bottle, and ſent back. Its ſtrength was ,21, and was greater than that of the undecanted part in the proportion of ,21 to ,16; ſo that, as not much of the undecanted part was

really congealed, the frozen part of the acid muſt have been much weaker than the reſt, if not mere water. Accordingly, during the melting of the undecanted part, the frozen particles ſwam at top. Mr. Mc Nab added ſnow to a little of the decanted liquor, but it did not diſſolve, and no increaſe of cold was produced.

19. From theſe experiments it appears, that ſpirit of nitre is ſubject to two kinds of congelation, which we may call the aqueous and ſpirituous; as in the firſt it is chiefly, if not intirely, the watery part which freezes, and in the latter the ſpirit itſelf. Accordingly, when the ſpirit is cooled to the point of aqueous congelation, it has no tendency to diſſolve ſnow and produce cold thereby, but on the contrary is diſpoſed to part with its own water; whereas its tendency to diſſolve ſnow and produce cold, is by no means deſtroyed by being cooled to the point of ſpirituous congelation, or even by being actually congealed. When the acid is exceſſively dilute, the point of aqueous congelation muſt neceſſarily be very little below that of freezing water; when the ſtrength is ,21, it is at – 17°, and at the ſtrength of ,243, it ſeems, from Art. 16. to be at – 44°¼. Spirit of nitre, of the foregoing degrees of ſtrength, is liable only to the aqueous congelation, and it is only in greater ſtrengths that the ſpirituous congelation can take place. This ſeems to be performed with the leaſt degree of cold, when the ſtrength is ,411, in which caſe the freezing point is at – 1°½. When the acid is either ſtronger or weaker, it requires a greater degree of cold; and in both caſes the frozen part ſeems to approach nearer to the ſtrength of ,411 than the unfrozen part; it certainly does ſo, when the ſtrength is greater than ,411, and there is little doubt but what it does ſo in the other caſe. At the ſtrength of ,54 the point of ſpirituous

congelation is 31°½, and at ,33 probably −45°¼; at leaſt one kind of congelation takes place at that point, and there is little doubt but that it is of the ſpirituous kind. In order to preſent this matter more at one view, I have added the following table of the freezing point of common ſpirit of nitre anſwering to different ſtrengths.

Strength.	Freezing point.	
,54	−31½°	ſpirituous congelation.
,411	−1½*	
,38	−45¼	
,243	−44¼	aqueous congelation.
,21	−17	

20. In trying the firſt half of the dephlogiſticated ſpirit of nitre, the cold produced was −44°½. The acid was fluid before the addition of the ſnow, and of the temperature of −30°, but froze on putting in the thermometer, and roſe to −5°, as related in Art. 7.

In trying the ſecond part, the acid was about 0° before the addition of the ſnow, and therefore had no diſpoſition to freeze. The cold produced was −42°½.

As the quantity of ſnow added in theſe experiments was not obſerved, they do not determine any points of aqueous or ſpirituous congelation in this acid; but there is reaſon to think, that theſe points are nearly the ſame as thoſe of common ſpirit of nitre of the ſame ſtrength, as the cold produced in theſe experiments was nearly the ſame as that obtained by the common ſpirit of nitre.

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* The point of eaſieſt freezing.

On

On the Vitriolic Acid.

21. On December 12, the ſtrong oil of vitriol N° 151. was found frozen, and was nearly of the colour and conſiſtence of hogs-lard. Its temperature, found by preſſing the ball of a thermometer into it, was − 15°, and that of the air nearly the ſame; but in the night it had been expoſed to a cold of − 33°. It diſſolved but ſlowly on being brought into a warm room, and was not completely melted before it had riſen to + 20°, and even then was not very fluid, but of a ſyrupy conſiſtence. During the progreſs of the melting, the congealed part ſunk to the bottom, as in ſpirit of nitre; and many air bubbles ſeparated from the acid, which, when it was completely melted, formed a little froth on the ſurface. As ſoon as it was ſufficiently melted to admit of it, which was not till it had riſen to the temperature of + 10°, the fluid part was decanted, and both were ſent home to be examined.

It is remarkable, that the frozen part did not intirely diſſolve until the temperature was ſo much increaſed. This would incline one to think, that the frozen part muſt have differed in ſome reſpect from the reſt, ſo as to require much leſs cold to make it freeze; but yet I could not find that the ſtrength of the decanted part differed ſenſibly from the reſt.

It appeared by another bottle of oil of vitriol, which alſo froze by the natural cold of the air, that this acid, as well as the nitrous, contracts in freezing.

22. On December 21, when the weather was at − 30°, the vitriolic acid N° 103. was diluted with ſnow, as directed in Art. 3. The ſnow diſſolved immediately, and no ſigns of congelation appeared during any part of the proceſs. The

temperature of the acid roſe only one degree before it began to ſink, and the weight of the ſnow added was only $\frac{10}{122}$ of that of the acid, ſo that its ſtrength was reduced thereby to ,605; which is therefore the beſt degree of ſtrength for producing cold by the addition of ſnow, when the degree of cold ſet out with is $-30°$. This ſtrength is one-fifteenth part leſs than what I found myſelf, by a ſimilar experiment, when the temperature of the acid was $+27°$; which ſhews, that the beſt degree of ſtrength is rather leſs, when the degree of cold ſet out with is great than when ſmall, but that it does not differ much.

23. The acid thus diluted was divided into two parts, and the next day Mr. Mc Nab tried what degree of cold could be produced by adding ſnow to one of them. The temperature of the air at the time was $-39°$, and the mixture ſunk by the proceſs to $-55°\frac{1}{2}$. The ſnow diſſolved readily, and the mixture did not loſe much of its fluidity until it had acquired nearly its greateſt degree of cold, nor did any congealed matter ſink to the bottom in any part of the proceſs. The quantity of ſnow added was about $\frac{86}{1000}$ of the weight of the acid, ſo that the ſtrength of the mixture was about ,325.

24. On January 1, thin cryſtals of ice were found diffuſed all through this mixture, the temperature of the air being $-51°\frac{1}{2}$, but that of the liquor was not tried. As this congelation muſt have been of the aqueous kind, and ſeems to have taken place at the temperature of $-51°\frac{1}{2}$, it ſhould follow, that this acid had no power of diſſolving ſnow in a cold of $51°\frac{1}{2}$; ſo that it does not at firſt appear why a cold four degrees greater than that ſhould have been produced in the foregoing experiment. The reaſon is, that at the time the mixture arrived at $-55°\frac{1}{2}$, it appeared by the diminution of its fluidity to have

contained ſome undiſſolved ſnow, and ſome more was added to it after that time, which before the firſt of January diſſolved and mixed with the acid; ſo that the acid in the mixture, at the time it ſunk to − 55°½, was not quite ſo much diluted as that which froze on January 1. This is the reverſe of what happened in the trial of the nitrous acid in Art. 15. as in that experiment the fluid part, at the time of the greateſt cold, was weaker than the whole mixture together; but it muſt be conſidered, that *that* mixture contained much congealed acid, as well as undiſſolved ſnow, whereas *this* contained only the latter.

25. On January 1, ſnow was added to the other half of the acid diluted on December 21. The cold produced was much greater than before, namely − 68°½; this ſeems to have proceeded, partly from the air and materials having been 12 degrees colder in this than in the former experiment, and partly from the ſnow having been added faſter, ſo that the mixture arrived at its greateſt degree of cold in 20′, whereas it before took up 46′. Another reaſon is, that the former mixture was made in too ſmall a jar, in conſequence of which it was poured into a larger before the experiment was completed, whereby ſome cold was loſt. The quantity of ſnow uſed in this experiment was leſs than in the former, ſo that the ſtrength of the acid after the experiment was about ,343. The mixture alſo grew much thicker, and had a degree of elaſticity reſembling jelly; but whether this was owing only to more ſnow remaining undiſſolved, or to any other cauſe, I cannot tell.

26. Great as the foregoing degree of cold is, Mr. M^c^ NAB, on February 2, produced one much greater. In hopes of obtaining a greater degree of cold by previouſly cooling the materials, he cooled about ſeven ounces of oil of vitriol, whoſe ſtrength was ,629, that is, rather ſtronger than the foregoing

by placing the jar in which it was contained in a freezing mixture of oil of vitriol and ſnow; the ſnow intended to be uſed was alſo cooled by placing it under the veſſel in which the freezing mixture was made. As ſoon as the acid in the jar was cooled to the temperature of – 57°½, a little of the ſnow was added, on which it immediately began to freeze, and roſe to – 36°; but in about 40 minutes, as the jar was ſtill kept in the freezing mixture, it ſunk to – 48°; by which time it was grown very thick and gritty, eſpecially at bottom. More of the cooled ſnow was then added, which in a ſhort time made it ſink to – 78°½, and at the ſame time the thickneſs and tenacity of the mixture diminiſhed; ſo that by the time it arrived at the greateſt degree of cold, very little thickneſs remained.

It is worth inquiring, what was the reaſon of the greater degree of cold produced in this than in the preceding experiment? It could not be owing to the materials being colder; for at the time of the ſecond addition of ſnow, at which time the experiment may be conſidered to have begun, the acid was not colder than at the beginning of the preceding experiment, and the ſnow in all probability not much colder. It could not be owing neither to the jar having been kept in the freezing mixture: for though that mixture was three or four degrees colder than the air in the preceding experiment, yet the acid in the jar, before it acquired much addition of cold, would be robbed of its cold faſter by the mixture than it would by air of the ſame temperature as that in the preceding experiment. Neither could it proceed from any difference in the ſtrength of the acid; for what difference there was muſt have done more hurt than good. The true reaſon is, that the acid was in a ſtate of congelation: for as the congealed acid united to the ſnow and became fluid by the union, it is plain, that cold muſt have been produced both by the melting of the ſnow and by that of the acid; whereas, if the acid had been in a fluid ſtate, cold would have been produced only by the firſt cauſe, and conſequently a greater degree of cold ſhould be produced in this experiment than in the former. The only inconvenience attending the acid being in a ſtate of congelation is, that in all probability it does not unite to the ſnow ſo readily as when in a fluid ſtate; but the difference ſeems not material, as the cold was produced, and the materials melted, in 5 minutes.

27. The day before, Mr. M^c^ NAB, by adding ſnow to ſome of the ſame acid in the uſual manner, when the cold of the materials was −46°, produced a cold of only −66°.

28. In theſe four laſt experiments the acid was reduced, by the addition of the ſnow, to the ſtrengths of ,325, ,343, ,403, and ,334; and the cold produced in them was before ſaid to be $-55°\frac{1}{2}$, $-68°\frac{1}{2}$, $-78°\frac{1}{2}$, and −66°; whence we may conclude, that theſe are nearly the points of aqueous congelation anſwering to the foregoing ſtrengths; only it appears, from what was ſaid in Art. 24. that the ſtrengths here ſet down are all of them rather too ſmall.

Though it is certain that oil of vitriol is capable of the ſpirituous congelation, and though it appears, both from the foregoing experiments and from ſome made by the Duc D'AYEN * and by M. DE MORVEAU †, that it freezes with a leſs degree of cold when ſtrong than when much diluted, it is not certain whether it has any point of eaſieſt freezing, like ſpirit of nitre, or whether the cold required to freeze it does not continually diminiſh as the ſtrength increaſes, without limitation; but the latter opinion is the moſt probable. For the Duc D'AYEN's and

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* Diction. de Chym. par MACQUER, 2^de^ edit.

† Nouv. Mém. de l'Académ. de Dijon, 1782, 1^er^ ſemeſtre, p. 68.

M. DE MORVEAU's acids, which, as they were concentrated on purpoſe, were moſt likely ſtronger than Mr. M^c^ NAB's, froze with a cold leſs than zero of FAHRENHEIT; whereas the freezing point of Mr. M^c^ NAB's undiluted acid, whoſe ſtrength was ,98, was – 15°, and that of the diluted acid, whoſe ſtrength was ,629, was – 36°; and when the acid was more diluted, it was found to bear a much greater cold without freezing. It appears alſo, both from Art. 21. and from M. DE MORVEAU's experiment, that during the congelation of the oil of vitriol, ſome ſeparation of its parts takes place, ſo that the congealed part differs in ſome reſpect from the reſt, in conſequence of which it freezes with a leſs degree of cold; and as there is reaſon to think from Art. 21. that theſe two parts do not differ much in ſtrength, it ſeems as if the difference between them depended on ſome leſs obvious quality, and probably on that, whatever it is, which forms the difference between glacial and common oil of vitriol. The oil of vitriol prepared from green vitriol, has ſometimes been obtained in ſuch a ſtate as to remain conſtantly congealed, except when expoſed to a heat conſiderably greater than that of the atmoſphere, whence it acquired its name of *glacial* *. It is not known indeed upon what this property depends, but it is certainly ſomething elſe than its ſtrength; for oil of vitriol of this kind is always ſmoking, and the fumes it emits are particularly oppreſſive and ſuffocating, though very different from thoſe of the volatile ſulphureous acid. On rectification likewiſe it yields, with the gentleſt heat, a peculiar concrete ſubſtance, in the form of ſaline cryſtals; and after this volatile part has been driven off, the remainder is no longer ſmoking, and has loſt its glacial quality *.

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* Mém. de l'Académ. des Sc. 1738, p. 288.

On the Mixture of Oil of Vitriol and Spirit of Nitre.

29. This mixture is not ſo fit for producing cold by the addition of ſnow, as oil of vitriol alone; for the cold obtained did not exceed $-54°\frac{1}{2}$, in either of the experiments tried with it. The point of ſpirituous congelation of this mixture, when diluted with ſomewhat more than one-tenth of its weight of water, is about − 20°, and is much lower when the acid is conſiderably more diluted: but as the Society will moſt likely have leſs curioſity about the diſpoſition to freeze of this mixture than of the ſimple acids, I ſhall ſpare the particulars.

On the Spirit of Wine.

30. The rectified ſpirits N° 8. were diluted with ſnow, in the ſame manner as the other liquors; but were found not to want any, as the firſt and only addition of ſnow produced cold. The quantity added was about $\frac{1}{26}$ of the weight of the ſpirit.

31. The ſpirit thus diluted was divided, like the other liquors, into two parts, and each tried ſeparately. The firſt was at − 45°, before the addition of the ſnow, and was ſunk by the proceſs to − 56°. The ſnow, even at the firſt addition, did not diſſolve well, ſo that the ſpirit immediately

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* Crell's Neu. Entdeck. in der Chemie, Th. 11. p. 100. Th. 12. p. 241, &c. and Annalen, 1785, St. 5. p. 438, &c.

became full of white ſpots *, and grew thick by the time it arrived at its greateſt degree of cold. After ſtanding ſome hours, the mixture roſe to the temperature of − 39°, and was grown clear, but yet was not limpid, but of the conſiſtence of ſyrup. No cold was produced by adding ſnow to it in that ſtate, though it appeared that its point of aqueous congelation was at leaſt 6 degrees lower than its temperature at that time †; which ſeems to ſhew that ſpirit of wine has ſcarce any power of diſſolving ſnow when it wants even 6 degrees of its point of aqueous congelation, and therefore is another inſtance that ſnow is diſſolved much leſs readily by ſpirit of wine than by the nitrous and vitriolic acids.

32. In trying the other part of the diluted ſpirits, the cold produced was only − 47°½, the cold ſet out with being − 37°.

33. It appeared by the diluted ſpirit of wine N° 143. which on December 12 froze by the natural cold of the atmoſphere, and was treated in the ſame manner as the diluted ſpirit of nitre, that when highly rectified ſpirit of wine, ſuch as N° 8. is diluted with $1\frac{4}{10}$ its weight of water, its point of aqueous congelation will be at − 21°. The congealed part of the ſpirit was white like diluted milk, and even the decanted part, which was full of thin films of ice, had a milky hue. The fluid part was ſtronger than the reſt, and no increaſe of cold was produced by adding ſnow to ſome of it, both of which are marks of aqueous congelation.

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[*] This was not the caſe during the above-mentioned dilution of the ſpirits; but the cold was 16 degrees leſs in that experiment than in this.

[†] On account of the dilution which the ſpirits ſuffered by the melting of the ſnow which remained undiſſolved at the time of the greateſt cold, its point of aqueous congelation was no longer ſo low as − 56°; but it ſtill was not leſs than − 45½, as in the evening it was found at that temperature, without much congealed matter in it.

Though the foregoing experiments confirm the truth of what I ſaid, in the account of Mr. HUTCHINS's experiments, concerning the cauſe of the cold produced by mixing ſnow with different liquors, and intirely clear up the difficulty relating to it which I mentioned in Art. 1. yet ſeveral queſtions may naturally occur; ſuch as, why the cold produced by the oil of vitriol was ſo much greater than that obtained by the ſpirit of nitre, notwithſtanding that in warmer climates the nitrous acid ſeems to produce more cold? and why the cold produced by the nitrous acid, notwithſtanding its previous dilution, which might naturally be expected to be of ſervice, was not greater than has been obtained by other perſons without that precaution? But as this would lead me into diſquiſitions of conſiderable length, without my being able to ſay any thing very ſatisfactory on the ſubject, I ſhall forbear entering into it. I will only obſerve, that in moſt of the foregoing experiments, Mr. M^c NAB would probably have produced more cold, if he had added the ſnow faſter. We ought not, however, to regret that he did not, as its effects on the acids would then have been leſs ſenſible.

The natural cold, when theſe experiments were made, is remarkable; as there were at leaſt nine mornings in which the cold was not leſs than that of freezing mercury; four in which it was at leaſt eight degrees below that point, or −47°; and one in which it was −50°. Whereas out of nine winters, during which Mr. HUTCHINS obſerved the thermometer at Albany Fort, there were only twelve days in which the cold was equal to that of freezing mercury, and the greateſt cold ſeems to have been −45°. I cannot learn whether the laſt winter was more ſevere than uſual at Hudſon's Bay; or whether Henley-Houſe is a colder ſituation than Albany, which may perhaps be the caſe; forthough it is only 130 miles diſtant from it, yet it ſtands inland, and to the W. or S.W. of it, which is the quarter from which the coldeſt winds blow.

Mr. Mc NAB's original account of the experiments which furniſhed the materials of this Paper, having been thought too long to be printed in detail, is depoſited in the Archives of the Society.

END OF PART I. OF VOL. LXXVI.